METHOD AND APPARATUS FOR PROVIDING INDUCTIVE COUPLING AND DECOUPLING OF HIGH-FREQUENCY, HIGH-BANDWIDTH DATA SIGNALS DIRECTLY ON AND OFF OF A HIGH VOLTAGE POWER LINE

Cross Reference to Related Applications

[01] This application claims priority under 35 U.S.C. § 119(e) from provisional application no. 60/268,578, filed February 14, 2001. The 60/268,578 provisional application is incorporated by reference herein, in its entirety, for all purposes.

Field of the Invention

[02] The present invention is concerned with the field of transmitting and receiving high frequency, high bandwidth signals safely and efficiently over power lines. An exemplary system comprises a power line coupler of the present invention, a fiber optic isolator and a communications interface to various media. More specifically, the present invention is drawn to a method and apparatus for coupling to a high voltage power line for transmitting and receiving high frequency, high bandwidth signals.

Background

[03] With well-established power distribution systems (PDSs) already in place throughout much of the world, an efficient power line communication system (PLCS) could provide more users with high-speed telecommunications access with the minimum investment of "add-on" devices.

[04] The infrastructure for providing broadband Internet access is presently insufficient to meet demand. A power distribution system (PDS), however, could be an ideal vehicle for carrying communications signals in order to meet this demand. Development of a power line communication system (PLCS) would therefore provide more users with high-speed telecommunications access. Since the PDS is

already built, the time required to implement a PLCS would be minimal.

[05] Of course, there are a series of problems to be overcome before a PDS can be used as an efficient, high-speed power line communications medium. The following issues, while not exhaustive, are representative considerations of what such a system would require in order to use an existing PDS to transport communication data: a sufficient signal to noise ratio; non-disruptive installation of the "add on" device; safety means such that users and circuitry are protected and isolated from stray current; a signal carrier with a frequency sufficient to support high data transfer rate (e.g. 10Mbps); means for the data signal to bypass a distribution transformer without loss; bi-directional data transmission; coupling devices that do not interfere with data signal handling; an independent power source for electronic conditioning circuitry at power line interfaces; a power line interface that is impervious to extreme environmental conditions; and means for the data to be readily routed to intended locations without loss.

[06] Given the advantages of being able to use the existing PDS for high-speed data communication, an effective method is required to couple and decouple the signals onto and off of a high or medium voltage power line. The coupling and decoupling of the data signal must be at a level sufficient to maintain an adequate signal to noise ratio in order to discern between the data signal and noise or interference on the line. For any method developed, a significant challenge lies in being able to mitigate the adverse effects of the high voltage 50-60Hz power signal might have on the communications signal.

[07] Whyte, et al. in US Patent 4,142,178 observe: "The use of the distribution network conductors for the transmission of carrier communication signals presents many problems not encountered in high voltage transmission line communication systems. Some of these problems include the poor high frequency impedance characteristics and the high level of electrical noise present on the distribution network conductors which, along with the plurality of distribution transformers and power factor correction capacitors attached to the distribution network, rapidly

attenuate the communication signals."

[08] Whyte teaches using a direct circuitry from a line coupler to a remote data terminal thus bypassing the PDS transformer, which is the primary source of data attenuation. The main use for the transmission of communication signals addressed by Whyte was to perform distribution functions such as automatic reading of utility meters and selective load control. Those functions are still desirable, but the function of high speed, high bandwidth communication transmission preclude direct connection from a transformer to remote data terminals economically.

[09] Use of a low voltage power distribution system as a data communications carrier within a premises is well known. Abraham, US Patent No. 6,014,386 teaches a communications network within a building using the AC wiring as the infrastructure of the network. Different types of appliances using digital signals may be included within the network. The Abraham patent uses an impedance matching scheme to direct a specific signal to a specific location. Couplers at a control location have unique impedances that are matched by corresponding couplers elsewhere within the building. Thus, specific signals will be de-coupled based an impedance match. Abraham also teaches the use of dielectric inductors in circuit with capacitors to tune the impedance characteristics of couplers.

[10] In a similar manner, Abraham in US Patent No. 5,625,863 teaches the distribution of multiple video signals distributed within a building using the building's AC wiring as the distribution system. Unique impedance settings direct the signals to unique locations. Abraham in US Patent No. 5,818,127 describes a distribution system for FM signals within a building by use of the building's AC wiring.

[11] Abraham in US Patent No. 5,717,685 describes the coupling of data signal on and off a building's AC wiring infrastructure. His invention uses capacitive circuits in serial connection. The circuitry also includes air-core transformers. This arrangement allows impedance tuning of the specific couplers. While Abraham claims a system with a fiber optic source for an input signal in his 6,014,386 patent,

there is no description as to the use of fiber optic isolators.

[12] Abraham also states that the utility firm may use the communications system to communicate utility meter information over the PDS.

[13] Methods for avoidance of distribution transformers are well known. Perkins in a series of patents including US Patent No. 4,473,816 teaches a communications signal bypassing a multi-phase power transformer where the signal uses the PDS as a carrier. The signal is bi-directional and uses conductive material to affect the bypass. The invention uses multiple capacitors in parallel to neutralize the coupling impedance. Further, the winding ratio, R, between the primary and secondary windings ratio is maintained in the signal frequency across the signal bypass. Signal carrier frequency is in the 3-10KHz range. Similarly, Perkins in US Patent No. 4,473,817 teaches a communications signal bypassing a single-phase power transformer.

[14] Kennon, US Patent No. 4,644,321 uses a non-intrusive coupler to capture the data signal. Kennon teaches the use of a toroid having a multiplicity of turns of a conductor that is in circuit with an amplifier and receiver. The toroid core is non-conductive. The signal thus inductively de-coupled is amplified and used for a load management and filed configuration utility terminal. The system requires a battery for circuitry management.

[15] Brown, US Patent 5,949,327 teaches the use of transformer bypass by coupling using capacitors connected to the primary and secondary terminals of the step transformer. Brown recognizes the need for multiple couplings at different points within the EDN (Electrical Distribution Network or, as referred to in the present description as PDS). Brown also teaches that the communication system use a high frequency signal carrier technique such as CDMA.

[16] Moore, US Patent No. 5,210,519, describes a communication system that couples data signal from a transmission source using an inductor and de-couples the data at the receiver. This methodology is applied in a closed network and

requires selective de-coupling as opposed to routing of the signal. Further, Moore teaches the use of a second transformer for reversing any inductor core saturation that may have occurred in the data de-coupling. This method requires time division of the data coupler between data coupling and saturation neutralization.

[17] Dzung, European Patent Application EP948143, describes a high voltage power line communication system that combines multiple source data signals, couples the combined signal onto multiple power lines using capacitive coupling and de-couples and demodulates the signals, separating and converting the signals back to the original form at the receiver.

[18] Power lines can be located in areas with extreme environmental conditions. Thus, the mechanical design must ensure proper operation when exposed to these extreme conditions and also maintain the required level of safety. Furthermore, any methods developed should be designed so as to have minimal impact to service of customers during installation.

[19] Public safety is an absolute requirement. Any system using the PDS must isolate the end user (and public in general) from exposure to electric current. The PDS steps medium and high voltage power down to low voltage power (approximately in the 100-240 volt range) using transformers. Transformers are designed to filter out and ground high frequency signals as a safety precaution. Since a high frequency signal carrier is the ideal medium for high bandwidth data transfer, a communications data delivery system needs to circumvent the transformer filtration process while preserving safety protection.

Summary of the Invention

[20] It is an object of the present invention to provide a power line coupler device for use with a power line communication system (PLCS).

[21] It is another object of the present invention to provide a power line coupler device for use with a high frequency signal carrier sufficient to support high data

transfer rates.

[22] It is still another object of the present invention to provide a power line coupler device that operates under the various line voltages within the PDS.

[23] It is yet another object of the present invention to provide a power line coupler device that enables electrical current isolation.

[24] It is still a further object of the present invention to preserve signal to noise ratio for the communications signal.

[25] It is yet a further object of the present invention to preserve signal to noise ratio for the communications signal bi-directionally.

[26] It is another object of the present invention to provide inductive signal coupling in a PDS.

[27] It is a further object of the present invention to provide inductive signal coupling in a PDS where the coupler's core remains unsaturated.

[28] It is a further object of the present invention to provide a power line coupler device that is non-intrusive.

[29] It is still a further object of the present invention to provide a power line coupler device that inductively draws operating power from the power line.

[30] It is a further object of the present invention to provide a power line coupler device that is self-contained

[31] It is a further object of the present invention to provide a power line coupler device that is self-contained and is nearly impervious to environmental conditions.

[32] It is another object of the present invention to provide a power line coupler device that uses a toroid inductor to inductively couple and de-couple signals to and from a power line.

[33] It is yet another object of the present invention to provide a power line coupler device that provides an electronic-to-light transducer to interface with a light conducting isolator.

[34] It is still another object of the present invention to provide a non-intrusive power line coupler device with a hinged power line coupler for ease of installation.

[35] The PDS topology can be used to deliver high-speed communications to residential homes in a cost effective way. Applications for such communication systems include high speed Internet, telephony, video conferencing and video delivery. This recitation of applications is not meant to be exhaustive.

[36] The system involves coupling and de-coupling communications data between a data source and a PDS. High frequency signals allow high bandwidth transfers (the higher the frequency of the data carrier, the more cycles per unit time available for data transfer). The signal carrier should exhibit high signal to noise characteristics relative to the underlying system of a 50 or 60 Hz PDS. (The US standard is 60 Hz, but most countries use a 50 cycle per second power system.)

[37] The data signals are coupled on to and off of the power line with a power line coupler (PLC) device. One embodiment of the present invention uses an inductive method to couple and de-couple data signals off of the power line. A toroid with conductive windings is placed around the power line. This method effectively provides a transformer between the power line and the PLC device circuitry thus facilitating the transmission and receiving of the data signal. For the primary side of the transformer, the number of windings and the orientation of the windings around the magnetic toroid is guided by the desire to maximize the flux linkage.

[38] The type of signal used on this channel can be almost any signal used in communications (CDMA, TDMA, FDM, OFDM to name a few). A wideband signal such as CDMA that is relatively flat in the spectral domain is preferred to minimize radiated interference to other systems while delivering high data rates.

[39] Since communications signals are very high frequency, a step down transformer would filter a signal coupled on the power line. The system to which present invention is a component avoids filtering of high frequency signals by bypassing the transformer with a power line bridge (PLB). The PLB, using a PLC device, de-couples data signals from the medium (MV) or high voltage (HV) line a short distance from a transformer. The PLB interfaces between the power line on the primary of the transformer and the low voltage (LV) line on the secondary of the transformer. (The primary is the side of the transformer where the relatively high voltage enters; the secondary is the side of the transformer where the stepped down, lower voltage exits the transformer.)

[40] The PLB is used to prevent the relatively high voltage from passing to the transformer's secondary side yet allowing the communications signal to pass between the PDS on either side of the transformer. The bypass is accomplished with the use of an isolator. The PLC device includes circuitry to interface with an isolator. A preferred embodiment of the system of which the present invention is a component is to use an optical medium as an isolator.

[41] The de-coupled signal from the relatively high voltage power line is converted to light energy (i.e. light signal) by using a transducer and transmitting the light signal over a non-electrically conductive but light conductive medium.

[42] A preferred embodiment of the present system uses a fiber optic cable as the isolator. The isolator is a light pipe that bypasses the transformer. Fiber optic cable is a dielectric thus insulating the PDS on the secondary transformer side from relatively high voltage.

[43] As described in a companion application by the present inventor, Application Serial No. 09/835,532 filed April 16, 2001, the signal is next modulated and de-modulated by a first modem. The signal goes through a data router and then a second modem. The router serves the purpose of matching data packets with specific messages and destinations. The second modem modulates and de-

modulates the signal in a form consistent with transport over a LV power line.

[44] The light signal is converted back to an electronic signal and then coupled onto the LV power line (LV coupler). In an embodiment of the present invention a second isolator is inserted in the system between the second modem and the data router for conversion of the light signal to electrical signal. Additionally the isolator proves an additional layer of safety because of the dielectric quality of the second isolator.

[45] The high speed, high frequency signal is then delivered, over the LV power line to the end user's residence or place of business. A power line interface device (PLID) serves as the gateway between the end user's various data appliances and local area network (LAN) and the high speed data transport.

Brief Description of Drawings

[46] **Figure 1** discloses the typical electric distribution topology of the prior art.

[47] **Figure 2** illustrates typical electric distribution topology modified for communication in accordance with the present invention.

[48] **Figure 3** illustrates a block diagram of the AP in accordance with the present invention.

[49] **Figure 4** illustrates a block diagram of the PLB in accordance with the present invention.

[50] **Figure 5** illustrates a conceptual diagram of a power line coupling in accordance with one embodiment of the present invention.

[51] **Figure 6** illustrates a diagram of a self-contained power line coupling in accordance with one embodiment of the present invention.

Detailed description of the Invention

[52] The present invention is a power line coupler device specially suited for

coupling and de-coupling high frequency, broadband signals carried over power lines within a power distribution system. The PLC device includes the coupler and circuitry necessary to condition the signal, to handle bi-directional signal transfer, to enable the use of an isolator, to be self-contained and to be able to provide operational power from the power line. The PLC device is part of an overall power line communication system (PLCS) which incorporates the present invention and other, companion inventions from the same inventor. The following description is a description of the PLCS in general. The PLC device embodiment is included in the system description. The description pertinent to the PLC device should be apparent to one skilled in the art.

[53] Referring to **Figure 1**, the typical electric distribution topology of the prior art is illustrated. Medium voltage (MV) half loop power delivery system, as illustrated, is common to the US PDS. Many transformers are used. Each transformer services a few homes or small businesses. Many other countries, such as the European states, use a high voltage delivery system with many end users serviced from a transformer. The present invention is applicable to either environment.

[54] The power line communication system may be implemented in a high voltage and medium voltage environment (i.e. 1-100kVAC). For purposes of this description and claims, the high and medium voltage portion of the PDS is described as primary voltage (PV). The low voltage portion of the system is described secondary voltage (SV). These terms are arbitrary but used to improve clarity of the description. Similarly, the side of a transfer where the PV line enters is called the "primary" side. The SV side of the transformer is referred to as the "secondary" side of the transformer.

[55] A sub-station **10** delivers PV power to a half loop distribution point, pole dip **12**. The power is delivered in parallel to multiple transformers **20** over a PV power line **14**. After the transformer is stepped down to a SV power (in the range of 100 to 240 VAC), several end user premises **26** are serviced via a SV power line **24**. The step down transformer **20** grounds high frequency signals for safety purposes. Since a

high data transfer (high bandwidth) power line communication delivery system requires a high frequency signal carrier, an object of the present invention is to avoid the removal of the high frequency signal by the transformer **20**. It is noted that the PV power lines **14** may be above ground or subterranean. The transformers **20** may be aerial mounted on a pole or pad mounted on the ground.

[56] **Figure 2** illustrates the typical electric distribution topology as shown in **Figure 1** as modified for communication in accordance with the present system. A point of presence **40** (POP), the gateway for high frequency, high bandwidth data signal, provides communications with digital providers. It both sends and receives data to the end user over the PDS. A backhaul link **42** connects the POP **40**. Data is manipulated and coupled and de-coupled from the PV power line at an aggregation point **44** (AP). A more detailed description of the AP follows in the **Figure 3** discussion.

[57] The PDS is viewed as having three channels: PV power line; SV power line; and the premise's wiring. The first channel (the PV cable) has the least amount of noise and least amount of reflections. This channel has the highest potential bandwidth for communications. This is important because it is the channel that concentrates all of the bandwidth from the other channels. The type of signal used on this channel can be almost any signal used in communications (CDMA, TDMA, FDM, OFDM to name a few). A wideband signal such as CDMA that is relatively flat in the spectral domain is preferred to minimize radiated interference to other systems while delivering high data rates.

[58] The second channel (SV line from the transformer to the premise) and third channel (premise wiring) have noise present from electrical appliances and reflections due to the "web" of wires. These channels support a lower bandwidth than the PV channel and they need a more intelligent (with more overhead) modulation scheme. There are several companies with chip sets to achieve good communications for local area networks (LANs) such as: Adaptive Networks (Newton, Mass), Inari (Draper, Utah), Intellion (Ocala, FL), DS2 (Valencia, Spain)

and Itran (Beer-Sheva, Israel). These devices would work well for the SV and premise channels.

[59] Data signal and power are carried over the PV power line **14** as previously stated. A power line bridge **46** (PLB) allows the data signal to bypass the transformer **20** thus avoiding the grounding of the high frequency data signal. More description of the PLB follows in the **Figure 4** description. The data signal after manipulation is delivered to the end user's premise. The data signal enters premise via the SV wiring. The end user may have a local area network (LAN) or have individual digital appliances.

[60] In one embodiment of the present system, the signal is carried through the premise's wiring **24** and is available to various digital appliances **29, 30**, including PC's, by a power line interface device **28** (PLID). The PLID **28** plugs into a standard electrical socket and allows the digital appliance to send and receive digital data. An alternative embodiment as described later, uses a communications interface located outside of the premise and the data signal is directly fed to the premise.

[61] Referring next to **Figure 3**, a block diagram of the AP **44** in accordance with the present invention is illustrated. The AP **44** is the point where digital data is coupled and de-coupled to the PV power line. Additionally, the data is processed so that it can be readily communicated. Data signal communication to and from POP **40** is provided by the backhaul link **42**.

[62] A backhaul interface **50** allows direct communication with POP **40**. The signal is passed through a high or medium voltage signal modem **52** (PV modem). An isolator **54** is used to prevent electric current from flowing between the PDS and the components leading to the POP **40**. The isolator **54** is made from dielectric material. The isolator, in a preferred embodiment of the present system, is a fiber optic light pipe. More description of the isolator and its components occurs in the description referring to **Figure 6**.

[63] The isolator **54** bridges between the PV modem **52** and a power line coupler **56**.

The PV modem **52** within the AP **44** conditions the signal for transmission over the PV power line **14**. When data is transmitted by the end user and is de-coupled off of the PV power line, the PV modem **52** conditions the signal for transmission back to the POP **40**.

[64] In one embodiment of the present system, the power line coupler **56** comprises, along with other components, an inductor having a toroid (donut-like) shaped core. The toroid core has permeability qualities to improve signal to noise ratio. More description of a preferred embodiment for the power line coupler is presented below. The inductor couples and de-couples a high frequency signal to and from the power line without invading the power line. Once the data signal has been coupled to the PV power line, it is transported on the PV power line **14**.

[65] Referring to **Figure 4,** a block diagram of the PLB in accordance with the present system is illustrated. The PLB **46** bypasses the transformer **20** linking the data signal between the PV power line and the SV power line. At either end of the PLB **46** is a coupler. A PV coupler **60** couples and de-couples signal with a PV power line **14**. A SV coupler **72** couples and de-couples signal with a SV power line **24**.

[66] An isolator is present between the PLB end couplers **60**,**72** and the interior of the PLB **46**. The isolators, a PV isolator **62** and a SV isolator **70**, are composed of dielectric material and insulate the balance of the PLB from potential electrical damage and user injury. A preferred embodiment of the isolator uses fiber optic material. The isolator is discussed in more detail below.

[67] A PV modem **64** modulates and de-modulates the signal to and from the PV isolator. The PV modem conditions the high frequency signals for transmission over the PV power line **14**. The SV modem **68** conditions the signal for communication over a SV power line. In one embodiment of the present invention, a data router **66** is between the SV modem **68** and the PV modem **64**. The function of the data router **66** is to prioritize and gather packets from all of the devices on SV power line

side PV power line side. The data router **66** provides data packet management of end user transmission.

[68] The signal (going to the end user) is coupled onto the SV power line by the SV coupler **72**. The SV power line **24** delivers the power service to an end user premise **26**. A "web" of wires distributes power and signal within the premise. The user draws power on demand by plugging an appliance into a power outlet. In a similar manner, the user may use a power line interface device **28** (PLID) to digitally connect data appliances, receiving and sending data signals carried by the power wiring.

[69] A PLID **28** can have a variety of interfaces to the subscriber's equipment **30**, **32**. Some examples are RJ-11 Plain Old Telephone Service (POTS), RS-232, USB, and 10 Base-T. A subscriber can have more than one interface device **28** on the same premise wiring.

[70] Referring to **Figure 5**, a conceptual diagram of a power line coupler device in accordance with one embodiment of the present invention is illustrated. The description of the system includes a PLB **46**. The embodiment conceptualized in **Figure 5** replaces the PLB **46** with a self-contained power line coupler device **100**, a fiber optic isolator **130** and a communications interface **140**. Further, the transformer **20** is depicted as pole mounted. The Communications Interface **140** separates signal carried over the PV power line **14** into three components: SV power line **24**; wireless link **150**; and telephone line **160**, although this is not meant as a limitation.

[71] Referring to **Figure 6**, a diagram of a self-contained power line coupler device in accordance with one embodiment of the present system is illustrated. The self-contained power line coupler device is packaged in a weatherproof housing **102** to militate against harsh weather and environment conditions. The PV power line **14** passes through openings in the container. A data signal coupler **104** couples and de-couples data signals transported by the PV power line **14**. One embodiment of

the present invention uses a magnetic toroid shaped inductor. Windings **108** are placed around the inductor **104** to facilitate flux linkage of the data signal. The number of windings and the winding orientation is selected to maximize flux linkage. The permeability of the magnetic core is chosen for maximum coupling with the high frequency data signal. Core permeability characteristics prevent low frequency power line signal saturation of the toroid core. If the inductor coupler **104** becomes saturated with low frequency signal, the coupler would lose its ability to couple or de-couple high frequency signal. Low frequency, as used in this description and claims, are frequencies in the range of 1-100 Hz, typically 50-60 Hz.

[72] The toroid **104** has direct electrical connection to the signal conditioning electronics used for transmitting and receiving the data signal. Transmit and receive circuitry **110** carries data signal to signal conditioning electronic components. As depicted in **Figure 6**, the transmit circuitry **112** and the receive circuitry **114** are in parallel. Another embodiment of the present invention uses two data signal coupling toroids. One coupler is used for receiving and one for transmitting in order to optimize the flux linkage for the two cases. (**Figure 6**, however, depicts only a single signal coupler.)

[73] The design of the transmit side is done to maximize the power of the drive signal in order to keep the signal to noise ratio of the coupled signal at least to the level acceptable for the overall communications system. The receive side contains a low noise amplifier designed to handle the lowest acceptable transmit signal level of the system. At a system level, the modulation and signaling scheme is done to minimize interference between transmit and receive signals.

[74] The signal conditioning circuitry communicates with the fiber optics interface via an electronic/light transducer **116**. Laser diodes may be used to implement a light transducer. The transducer converts electrical signal to light signal in the receive circuitry **114**. The transducer converts light signals to electrical signals in the transmit circuitry **112**. The light signal is transmitted to and from a light pipe **130** (fiber optic cable). The data signals are communicated back and forth between the

power line coupler **100** and the Communications Interface **140** via a fiber optic cable **130**. The Fiber Optic Isolator breaks any electrical path between the two devices thus providing safety for the system.

[75] With the power line coupler device being a "closed" system, power for the electronics must be derived internally. Batteries may be an option but replacement would be costly and impractical. In one embodiment of the power line coupler device, a power draw toroid **106** is provided. The power draw toroid **106** has magnetic characteristics appropriate for coupling low frequency signals, thus inductively drawing some of the power off of the power line and providing a power supply **118** for the power line coupler device.

[76] For additional safety, the power line couple device external shell or housing **102** is constructed from dielectric, corrosive resistant, weatherproof materials and is designed to significantly reduce any possible exposure to the high voltage potential present on the power line. The Fiber Optic Isolator **130** is the only connection between the power line coupler device **100** and the communications interface **140.** Further, the light pipe is encased in the insulated housing **102**. The first priority of the housing **102** is to protect from exposure to the high voltage potential. It is also designed to ensure proper operation under extreme environmental conditions. The external shell is assembled using fasteners including adhesives. The assembled shell is sealed with a dielectric, weatherproof sealant around any seams, fasteners, and power line and conduit openings. Sealing enhances the weatherproofing.

[77] In another embodiment of the present invention, a "hinged" toroid design allows for easy installation and minimal impact to customer service. The toroids, one or two coupling toroids and a power supply toroid, simply snap around the power line using existing utility tools and techniques.

[78] The communications interface **140** communicates with the power line coupling device **100** via the fiber optic isolator **130**. Received signals are separated into digital data signals and any other communication signal that may be carried by the

PV power line. **Figure 5** depicts three types of leads from the communications interface: 120/240V power line **24** (SV power line); wireless link **150**; and telephone link **160**. The SV power line receives current from the transformer **24**. The digital data signal is coupled on and off the SV power line **24** within the communications interface.

[79] The description of one embodiment of the present system including a PLB **46** for providing a means for converting light signals to coupled digital data signals as delivered to a premise over SV power line has been made. The communications interface implements the coupling and de-coupling of digital data signal on and off the SV power line in a similar fashion.

[80] A system as disclosed herein is useful to provide data services to the residential market place at 10 Mbps. This makes an entire new range of applications practically available. Each device connected to the PLID would (if desired) have an address and would be accessible remotely. Some examples include broadband Internet access, remote utility meter reading, Internet Protocol (IP)-based stereo systems, IP-based video delivery systems, and IP telephony.

[81] The present system and the present invention have been described in terms of preferred embodiments. However, it will be appreciated that various modifications and improvements may be made to the described embodiments without departing from the scope of the invention.